

Significant Ottoman Mathematicians and their Works

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by: Salim Ayduz This article aims to give an overview of the formation and development of mathematical studies and the work of famous mathematician in the Ottoman State over a 600 year period, from the period preceding the conquest of Constantinople to the early 20th century. Dozens of mathematicians and hundreds of mathematical works flourished and they constitute rich material for ongoing investigation.

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1. Introduction

The Ottoman state began as a local principality at the turn of the 14th century. It became the most powerful state over a vast area extending from Central Europe to the Indian Ocean. During the 600 years of its existence, alongside the political events, the development of scientific and cultural activities played a crucial role on the cultural and scientific fronts. As a continuation of previous Muslim-Turkic states, the Ottomans inherited scientific and cultural riches from the Golden Age of Muslim Civilisation, from the 9th century onwards. With this legacy, they improved and established their own schools. Scientific activities emerged and developed from the base of the pre-Ottoman Seljukid period in Anatolian cites by benefiting from the works of scholars, who came from different corners of Islamic lands such as Egypt, Syria, Iran, India and Turkestan. The new Ottoman scholars and intellectuals, brought a new enthusiasm to cultural and scientific life. Beside Istanbul, many new centers flourished throughout the Ottoman lands, particularly in the Balkans and other European territories in places such as Bursa, Edirne, Istanbul, Skopje, and Sarajevo. This article aims to give an overview of the formation and development of mathematical studies and present bio-bibliographies of some famous Ottoman mathematicians over a six hundred years period. **

2. Mathematicians before the conquest of Constantinople

Most of the scholars during the first two centuries of the Ottomans came from Muslim countries and Turkish municipalities. The first Ottoman school (*madrasa*, pl. *madrasas*) was built in Iznik (Nicea) [1] in 1331 by the second Ottoman ruler Gazi Orhan Beg (c. 1326-1359) just after he conquered the city in 1331. Gazi Orhan Beg established many foundations in order to meet the financial needs of the *madrasa*. The Iznik *madrasa* trained the student in religious sciences (*al-'ulūm al-diniyya*) in their totality, and famous religious scholars such as Dāwūd al-Qaysarī (d. 1350) [2], Tāj al-Dīn al-Garadī (d. c. 1360) and Ala al-Dīn Aswad (d. 1393) taught in this *madrasa*. After the conquest of Bursa and Edirne, new schools and other educational buildings such as medical institutes and primary schools opened and scholars started to flock to the Ottoman cities. Scholars from different backgrounds produced very important books on various subjects including mathematics and astronomy. In this study, we will analyze the research and teaching

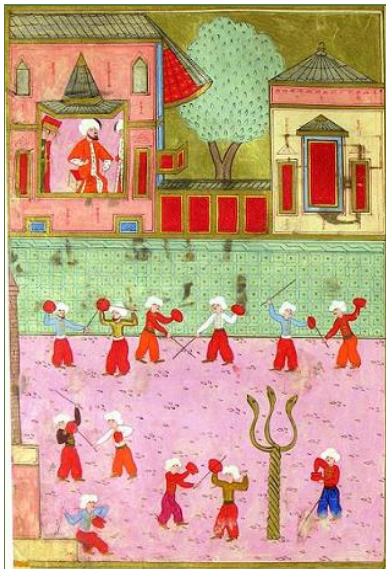


Figure 1: An Ottoman miniature showing a game of Matrak invented by Nasūh 'Alī al-Silāhī al-Matrāqī. Source: Topkapı Palace library in Istanbul, MS H 1344.

achievements performed by eminent Ottoman mathematicians and study their works.

The turning point in the history of *madrassa* teaching and the shift from the traditional Nizamiya madrasa system towards a more comprehensive institutional model took place during the time of Muhammad II. There are several reasons for this new orientation. First, it was the personal interest of Sultan himself in the rational sciences and his support of the scholars; second, this new tradition seems to draw directly from the Ilkhanid and Timurid institutions of learning, which included the teaching of the rational sciences. Muhammad II founded the Fatih Complex, which bore his name, between 1463 and 1470. It included eight intermediate madrasas called '*tatimma*' and eight other highmadrasas called '*sahn*' (literally courtyard).

The history of mathematical and astronomical literature during the Ottoman period records that numerous copies of astronomical and mathematical works were produced in the *madrassa* system. On the other hand, we note that from the 16th until the 19th century, there was an increase in the number produced [3].

For instance, Qādīzāda's (d. 1432) two works on astronomy and mathematics *Sharh al-Mulakhkhas fi al-Hay'a* and *Tuhfat al-Ra'is fi Sharh Ashkāl al-Ta'sis* were two basic textbooks for students who wished to study these subjects. There are more than three hundred extant copies of the former and approximately two hundred copies of the latter. Among these copies there are a considerable numbers which were copied in the schools of Anatolia and Istanbul [4].

3. General overview of Ottoman mathematics

After the conquest of Istanbul by Muhammad the Conqueror (1451-1481) in 1453, the Sultan himself began to set up a science centre in Istanbul. In the Library of the Palace of the Sultan, we find copies of numerous books about medicine, arithmetic, geometry, astronomy which were published in other countries during his time. During his reign, Muhammad II invited famous scholars to study in Istanbul at his *Madrasas*. During his reign, new educational institutions, such as the Sahn-i Sāmān Madrasas and the Enderūn Palace School in Istanbul, were established. As a result, some brilliant scholars emerged and made original contributions to science during his reign. The works of 'Alī al-Qushjī (d. 1474) and Fathullah al-Shirwānī's (d. 1486) two students of Qādīzāda al-Rūmī (d. ca 1440) from Samarkand, made notable mathematical contributions. Muhammad II patronized Muslim and non-Muslim scholars in Istanbul and ordered Greek scholars to translate Ptolemy's *Geography* into Arabic and to draw a world map. In addition to Muslim scholars from the Muslim world, he also invited artists and scholars from Europe especially Italy. Muhammad II also encouraged the scholars of his time to produce works in their fields.

In the Ottoman school system, mathematics and geometry were studied before the *Hadith* and the Quran studies. Muhammad b. Abu Bakr al-Marashi stated in his book *Tartīb al-'Ulūm* (written in 1715) that in the Ottoman schools, the students could learn geometry, cosmology and literature at any time, but arithmetic had to be studied as a compulsory science by all Muslims. It is possible to understand from the autobiographies of Ottoman scholars how the mathematic courses were planned in the curriculum. In the autobiography of Sheik al-Islam Feyzullah Efendi (d. 1703) it was stated that arithmetic, geometry and astronomy courses were taught with the courses of *Hikma* (wisdom) and *Tafsir* (explanation of the Quran) [5]. There are some records stating that arithmetic was also taught in religious institutions such as the *takkas* and *zaviyas* (Darwish lodges)[6].

In his book *De La Littérature des Turcs*, Abbé Toderini (lived in Istanbul between 1781 and 1786) stated that the Turks learnt arithmetic from well-written Turkish -Arabic course books and were as well informed as a European mathematicians. In the geometry section of *De La Littérature*, Toderini describes geometry instruction in the Ottoman madrasas:

"Geometry falls under the group of Turkish studies. In academies (*madrasa*), there are professors (*mudarris*) for teaching it [geometry] to young people. The period between mathematics and rhetoric classes is allocated to this mathematical branch... This science is taught in a special manner. I have been to the Valide Madrasa twice, during which time students had gathered to listen to the geometry class. They used an Arabic translation of Euclid. There are many versions as well as commentaries of this book. Nasīr al-Dīn al-Ṭūsī's commentary, which is regarded as the best of these, has already become popular thanks to the Medicis Publishing House. This copy contains a copy of the Turkish license granted by Sultan Murad III (1574-1595) in Istanbul in 1587 [7]. He has granted permission for the sale of this book without any tax or liability within the entire Ottoman territory..." [8]

Students in the Ottoman schools were allowed to teach arithmetic under the supervision of their teachers after a certain level of education. This means that after theoretical education the students had the opportunity to apply their knowledge. It is observed that in 19th-century mathematics education also became important in high schools. It is known that some of the Ottoman scholars learnt higher mathematics and algebra in high schools.

The Ottoman scholars wrote many textbooks on mathematics and also translated other important ones written in other countries. In arithmetic, they mostly used books written by Muslim mathematicians. For instance, *al-Muhammadiyya fī al-Hisāb* written by Ali al-Qushjī and *Khulāsāt al-Hisāb* written by Bahā al-Dīn al-ʿĀmilī were the widely used course books in arithmetic. Today there are more than forty copies of the *Muhammadiyya* in the libraries of various countries. We know of sixteen Arabic copies in Turkish libraries and two other ones in Cairo and in Aleppo [9].

Bahā al-Dīn al-ʿĀmilī's *Khulāsāt al-Hisāb* was a course book throughout the Ottoman school system from the 17th century. Kuyucaklızāda Muhammed Ātif (d. 1847) translated the book into Turkish with commentaries as *Nihāyat al-Albāb fī Tarjamati Khulāsāt al-Hisāb*. This was in 1826 during the reign of Mahmud II following his request to understand the original book easily [10]. For three centuries, this was one of the most common textbooks for students. It was studied as a textbook in the Ottoman State, Persia, India, and Egypt and it was translated into German in 1843 by Nesselman and also into French in 1846 by A. Marre. Some books written in Europe in the 19th century contained quotations from *Khulāsāt al-Hisāb*. The final editions of the book were in Istanbul in 1879 and in Cairo in 1894. There are more than one hundred copies of the book in Turkish libraries [11].

The Ottoman scholars started to write arithmetic books from the beginning of the 15th century onwards. Arithmetical texts were translated into Turkish after those of astronomy, but before texts of geometry. The titles of some are *Miftāh al-Hisāb* (anonymous), *Risāla fī ilm-i Hisāb* (anonymous) and *Miftāh al-Mushkilāt* (Muhammed Musa-i Wāfi). The arithmetic books which were prepared by the *Muhasipler* (account scribes) and *diwan katipleri* (secretaries of the Council of State) were usually written in Turkish.

The book entitled *Majma'-l qawā'id-i 'ilm-i hisāb* written by Hajji Atmaca in 1484 is an example of this. The greatest among the Turkish books of arithmetic which was written in the classical tradition, was *Tuhfat al-A'dad li-zawī al-rushd wa al-sadād* written by Ali b. Veli Hamza b. al-Jazāirī al-Maghribī (d. 1614) in 1590 and was presented to Sultan Murād III (d. 1595). This book shows that symbols and notation in algebra were used commonly by Ottoman mathematicians [12]. The other famous arithmetical books are *Nuzhat al-*

Hussab fī 'ilm al-Hisāb, al-Luma fī al-Hisāb, al-Ma'una fī al-Hisāb al-Hawa' written by Ibn al-Ha'im (d. 1412) and *Talkhīs A'māl al-Hisāb* written by the Moroccan mathematician Ibn al-Bannā (d. 1321). Although these authors were not strictly Ottoman citizens, their books were common in the Ottoman lands and were widely read and translated.

The Ottoman scholars also wrote and translated course books about algebra. Some of the book relating to algebra are *Al-Yawakīt Al-Mufasssalāt bi-'l-La'ali al-Nayyirāt fī A'māli Zawāt al-Asmā wa-'l-Munfasilāt* written by Jamal Al-Dīn Muhammed b. Ahmad b. Muhammad b. Pīrī al-'Alwānī, also known as Ibn Pīrī (d. 1631) [13]; *Al-Mawāhib al-Saniyya fī Ilm al-Jabr wa-'l-Muqābala* and *Sharh al-Yasminiya fī al-Jabr wa-'l-Muqābala* written by Ibn Al-Jamal (d. 1662); *al-Mustahzarat fī Hisāb al-Majhulāt* by Kuyucaklızade Muhammed Atif (d. 1847) and *Tuhfat al-Hisāb* by Ali Bahar Efendi (d. 1805) [14].

The Ottoman scholars were interested in logarithm because of the preparation of the star tables. They wrote and translated some books about logarithm. In 1780 Sekerzāda Feyzullah Sermed (d. 1787) translated the book entitled *Maqsadayn fī Hall Al-Nisbatayn* from a Hungarian mathematician. In this book, he defined the logarithm and explained the applications of logarithm in astronomy. The other books written by Ottoman scholars about logarithm are *Sharh al-Jadāwil al-Ansāb* by Gelenbevī Ismail Efendi in 1787; *Logaritma Risālesi* by Huseyin Rifki Tāmānī (d. 1817) and *Logaritma Risālesi* by Muftuzade Osman Saib (d. 1864) [15].

The *Hendesehāne-i Humayun* (Royal Mathematical School) was the first institution that was designated for modern military technical education in the Ottoman State. The *Hendesehāne*, which was called the '*Ecole des Théories*' or the '*Ecoles des Mathématiques*' in French, was established at the Royal Shipyard on 29 April 1775. In addition to the Ottoman teachers, Baron de Tott and a French expert taught courses. The institution had up to ten students and later assumed the name of the *Muhendishāne-i Humāyūn* (Royal School of Engineering) [16].

A great number of French and a few English engineers, teachers and officers came to Istanbul between 1783 and 1788, with the renewed closeness between the Ottomans and the French. However, all the French experts and foremen left Istanbul as the result of the alliance formed between Russia and France when the Ottomans entered into war against Russia between 1787 and 1788 [17]. It was observed that foremen and workers from other European states (some from Sweden) were employed after the French departed. When all the French experts and officers returned to their country between 1787 and 1788, the applied mathematics courses were discontinued and only the theoretical mathematics courses continued, given by Ottoman scholars, such as Gelenbevī Ismāil Efendi (d. 1790) and Palabiyik Muhammad Efendi (d. 1804).

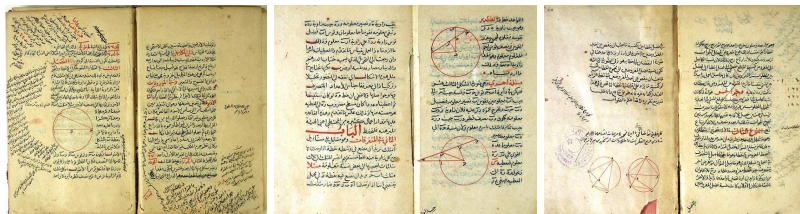


Figure 2, 3 & 4: Sample pages of Taqī al-Dīn ibn Ma'rūf's *Hisāb al-munanajjim wa-'l-jabr wa-'l-muqābala*. Source: Süleymaniye library in Istanbul, Carullah collection, MS 1454.

4. Ottoman mathematicians in the 15th and 16th centuries

4.1. Qādizāda al-Rūmī (d. ca 1440)

His full name was Salah al-Dīn Musa ibn Muhammad ibn Mahmud Qādizāda al-Bursāwī al-Rūmī. He was

born in Bursa, Turkey, (hence his name al-Rūmī, from the Arabic name al-Rum for the Byzantine and Ottoman States). His grandfather and father were judges/Qādī in Bursa. He received his preliminary education in mathematics and cosmology in the province of Bursa and then went to Samarkand. He became the teacher of Ulugh Beg (d. 1449) in astronomy and later on was appointed the chief instructor at the school of Samarkand and the director of the observatory founded by Ulugh Beg (d. 1449). He died there and was buried by Ulugh Beg in the mausoleum of Shāh-i-zinda (Living King) in Samarkand.

Qādīzāda al-Rūmī made the first important contribution to the development of the Ottoman scientific tradition and literature on mathematics and astronomy. He flourished in Anatolia and settled in Samarkand after compiling his first work. He wrote *Sharh Mulakhkhas fī'l-hay'a* (Commentary on the 'Compendium on Astronomy') and *Sharh Ashkāl al-Ta'sīs* (Commentary on The Fundamental Theorems) in Arabic in the fields of astronomy and mathematics. He simplified the calculation of the sine of a one degree arc in his work *Risāla fī Istikhrāj Jaybi Daraja Wāhida* (Treatise on the Calculation of the Sine of a One Degree of the Arc).

Qādīzāda's two students 'Alī al-Qushjī (d. 1474) and Fathullah al-Shirwānī (d. 1486) influenced Ottoman science by disseminating work on mathematics and astronomy. In the introduction to his *Tuhfat al-Ra'is Fi Sharh Ashkāl al-Ta'sīs* (Gift of the Chief in the Commentary on The Fundamental Theorems), he indicated that the philosophers who ponder about the creation and the secrets of the universe, the jurists (*faqih*s) who give *fatwās* in religious matters, the officials who run the affairs of state, and the *qādīs* who deal with judicial matters should know geometry. Thus, he emphasized the necessity of science to philosophical, religious, and worldly matters. This understanding reflects a general characteristic of Ottoman science.

In addition to the above, Qādīzāda wrote other books on mathematics and astronomy, made significant contribution to the preparation of *Ulugh Beg's Zij* [18] and wrote many commentaries on astronomical and geometry books. We present them below.

- *Tuhfat al-Ra'is* mentioned above [19]: Qādīzāda wrote this commentary on Samarkandī's *Ashqāl al-ta'sīs* which is a summary of the theorems and triangles in Euclid's *Usūl al-handasa*. It was completed in 1412 and presented to Ulugh Beg. There are approximately two hundred copies of this treatise in libraries [20].
- *Risāla dar bayān-i istikhrāj jayb-i yak daraja* (Treatise on Explanation of Determining the Sine of One Degree) by operations based on rules that are based on Arithmetic and geometric by principles of the Method of Ghiyāth al-Dīn al-Kāshī. Although it is a commentary on the treatise of al-Kāshī titled *Risāla al-watar wa'l-jayb* (Treatise on Chord and Sine), due to the originality of the subject, al-Rūmī is often regarded as the author of the treatise [21]. According to Salih Zeki (d. 1921), it is the most important treatise by him [22].
- *Risāla fī al-misāha* (Treatise on surveying), in Persian: In the prologue of the treatise, al-Rūmī explains why he composed this book saying that "some of my friends and tax officials asked me to write a treatise to solve their problems on the measurement (surveying) calculations. Therefore I composed this treatise." The treatise was divided into four chapters (*Ruqun*) and twelve sections (*qāidah*) [23].

4.2. 'Alā al-Dīn 'Alī al-Qushjī (ca 1402-1474)

This scholar's full name is Qushci-zāda Abu al-Qāsim 'Alā al-Dīn Ali b. Muhammad. He was born in Samarkand in the early 15th century. His father was Ulugh Beg's official falcon trainer; he came to be known as "Qushci-zāda" or "Qushjī." He received advanced education from outstanding scholars such as Ulugh Beg, Giyāth al-Din Jamshīd al-Kāshī and Qādīzāda al-Rūmī. He is also known for his contributions to Ulugh Beg's *Zij* which was prepared on the basis of the observations conducted at Samarkand Observatory under the guidance of Ulugh Beg.

After Ulugh Beg's demise in 1449, he left Samarkand first for Herat, then Tabriz and finally Istanbul. While he was in Tabriz, Uzun Hasan [24] sent 'Ali al-Qushjī as an emissary to Muhammad II, who was impressed by him. Ali al-Qushjī and Muhammad II had many scientific discussions. Sultan Muhammad was very pleased with him and asked him to remain in Istanbul permanently. Accepting the invitation, 'Ali al-Qushjī came to Istanbul with his family after the end of his duty as emissary (around 1472). Appearing before Sultan Muhammad, he presented the Sultan with the mathematical treatise *al-Muhammadiyya*, which was dedicated to him. Having been appointed as a *Mudarris* (teacher) of the Hagia Sophia school of Sultan Muhammad, 'Ali al-Qushjī spent the last couple of years of his life in Istanbul where he died in 1474.

A teacher of many students during his life, 'Ali al-Qushjī was a polymath scholar and a particular authority on astronomy and mathematics as well as many different disciplines such as language, religion, philosophy and mathematical sciences. He introduced new ways of understanding and exploring these disciplines and his works made an impact on scientific activities in both the Muslim and European worlds. He was instrumental in the importation of the Timurid Samarkand tradition to the Ottomans.

'Ali al-Qushjī was the author of many works on mathematics, astronomy, philosophy, and language, some of which were the outcome of original research, whilst others were textbooks for teaching or treatises focusing on specific problems. He wrote twelve works on mathematics and astronomy. One of them is his commentary in Persian on the *Zīj-i Ulugh Beg*. His two works in Persian, namely, *Risāla fī al-Hay'a* (Treatise on Astronomy) and *Risāla fī al-Hisāb* (Treatise on Arithmetic) were used as a course book in the Ottoman schools. He revised these two works in Arabic with some additions under new titles, *al-Fathiyya* (Commemoration of Conquest) and *al-Muhammadiyya* (The Book Dedicated to Sultan Muhammad), respectively. Both books won approval and were translated into other languages. Many commentaries were written about them. Altogether Ali al-Qushjī wrote 32 books and treatises, although some of his works are regrettably lost [25]. Copies of those works which have survived have made their way into modern-day libraries. His important works are listed below.

- *Al-Risāla al-Muhammadiyya fī al-hisāb* (Arabic): Treatise on Arithmetic. It was dedicated and presented to Sultan Muhammed II. Al-Qushjī used the terms "*muthbat*" and "*manfi*" for added and subtracted quantities instead of the standard terms "*zā'id*" and "*nāqis*". Al-Qushjī's terms are translations of Chinese terms and are presently used for positive and negative quantities in Iran, Turkey, Central Asia, and Azerbaijan; European terms for these quantities came from al-Qushjī's terms through Byzantine mathematicians [26].
- *Risāla dar ilm-i hisāb* (Persian): Treatise on the Science of Arithmetic. Also known as *Mizān al-hisāb* (Balance of Arithmetic) and *Zubdat al-hisāb* (Essence of Arithmetic). It contains three books: Indian arithmetic, sexagesimal fractions, and geometry.
- *Risāla fī al-qawā'id al-hisābiyya wa'l-dalā'il al-handasiyya*: Treatise on Arithmetic Rules and Geometric Indications [27]. It is a treatise on the sine of 1° .
- *Risāla dar hisāb u handasa* (Persian): Treatise on Arithmetic and Geometry.
- *Risāla fī istikhrāj maqādir al-zawayā min maqādir al-adlā' fī al-muthallathāt al-ghayr qā'imāt al-zawayā al-hāditha min qisiyy al-dawā'ir al-'izām*: Treatise on Determining the Magnitudes of Angles of a Triangle by the Magnitudes of Sides in Non-Rectangular Triangles Consisting of Arcs of Great Circles [of a Sphere]. (Suleymaniye Library, Carullah collection MS 2060).

4.3. Khalil al-Husayni (15th century)

Khayr al-Dīn Abū 'Abdullāh Khalīl ibn Ibrāhīm al-Husaynī was another mathematician, who worked in Istanbul at the court of Muhammad II [28]. There is very limited information about his biography. Two of his significant works on mathematics have reached today. His works are mainly on the subject of accounting mathematics.

1. *Miftāh-i kunūz-i arbāb-i qalām wa misbāh-i rumūz-i ashāb-i raqam*: (Persian) (Key to Treasures of the Masters of the Pen and Lamp of Symbols of Rulers of Figures). It is also known as *Risāla fī al-hisāb* (Treatise on arithmetic). The Treatise is dedicated to Muhammad II and divided into an introduction (*muqaddimah*), ten chapters and one epilogue (*khātimah*). Chapters 1-4 deal with different kinds of multiplication, 5-6 are devoted to different kinds of division, chapter 7 is on problems, 8-10 are dedicated to extraction of roots of 2nd, 3rd, and 4th powers [29]. This treatise was very well known and circulated among the state (*diwān*) accountants. It was compiled for their daily use for accounting calculations. The name of Muhammad II was cited in the introduction (*muqaddima*). It was translated into Turkish by Khalil al-Husayni's student Pīr Mahmud Sidkī al-Edirnevī. The section on the *khata'ayn* rule (double mistake) was translated into Turkish by Muhyi al-Dīn Hajji Atmaca al-Katib [30].
2. *Mushkil gushā-yi hisāb u mu'dil numā-yi kitāb* (Book of Difficulties in Arithmetic Solutions and those that are Incomprehensible), in Persian. Also known as *Mukhtasar fī al-hisāb* (Concise [Book] on Arithmetic) [31], it was dedicated to the Sultan Beyazid II (1481-1512) and divided into an introduction, six sections and an epilogue (*khātimah*) [32].
3. *Risāla-i Jabr u-Muqābala* (Persian). It was not cited by any sources and there is only one copy at Nuruosmaniye Library, MSS 2980/2 [33].

4.4. Yusuf Sinan Pasha (d. 1486)

Sinān al-Dīn Yūsuf ibn Khidr Beg ibn Jalāl al-Dīn (d. 1486), known by the names "Sinan-Pasha" and "Khwājā Pāshā", was the vizier of Sultan Muhammad II; he worked in Istanbul and Edirne. He was a well known historian, theologian, mathematician and astronomer [34].

He has only one work on mathematics: *Risāla fī Bāyani Mas'alatin Handasiyya or Risāla fī Istihrāci Zāviye Hadde 'Izā Furida Harakatu Ahadi or Risāla fī al-munfarija ta'sīru hadda qabla an ta'sīra qā'ima*; (Treatise that Obtuse (Angle) can become Acute without being Right) [35]. Ihsan Fazlioglu worked on this short treatise and published it with a lengthy analysis [36].

4.5. Hajji Atmaca al-Kātib (d. after 1494)

Muhyi al-Dīn al-Hajjī Muhammad ibn al-Hajjī Atmāja al-Kātib was a mathematician of the 15-16th centuries [37]. We have no information about his life. Most probably, he was one of the accountants for the State *Dīwān* [38]. He lived during the reigns of Muhammad II and Bayezid II.

He wrote two works on arithmetic:

1. *Majma'-i qawā'id-i 'ilm-i hisāb/Jāmi' al-qawā'id* (Collection of rules of the science of arithmetic), in Turkish. It was completed in 1494 and dedicated to the Sultan Bayezid II. It is an account book which was composed for scribes and accountants who were working for the administration. In the epilogue, he explains why he prepared this book saying that in the state administration, accountancy apprentices need to learn accounting mathematics through this book. He also indicates that most of the books on this subject are written in either Arabic and Persian, hence new staff need a book in Turkish in this subject to understand it easily [39]. The book contains three chapters and a prologue (*tatimma*): the first chapter is about integers; the second on calculations with rational numbers and in the third chapter there are forty problems with solutions. It was very commonly used among court scribes until the last centuries of the Ottoman state [40].
2. *'Ilm al-hisāb* (Science of Arithmetic) [41].
3. He also translated the sixteenth chapter of Khayr al-Dīn's book *Miftāh*'s as an independent treatise with the title *Tarjamat al-fasl al-sādith 'ashara fī bayan al-khatā'ayn min miftah-i kunūz-i arbāb-i kalām wa*

misbāh-i rumûz-i ashâb-i raqam [42].

4.6. Lutfullah al-Toqātī (d. 1494)

His full name is Lutfullah Muhammad bin Hasan al-Toqati, also known as Molla Lutfi (d. 1494). He was born in Tokat (Turkey). There is very limited information about his life; he studied mathematics under Sinan Pasha and later advanced studies with Ali al-Qushjī. When Sinan Pasha was appointed as a Grand Vizier to the Sultan Muhammad II, Molla Lutfi was also appointed as the librarian of the Sultan in his personal library at the palace. When Sinan Pasha was exiled to Sivrihisar, Molla Lutfi was also removed from his post and accompanied Sinan Pasha. When Bayezid II ascended to the throne, they were pardoned and Molla Lutfi was appointed to a madrasa in Bursa as a *mudarris*. Later he moved to Edirne as a *mudarris* (teacher), returned to Bursa, then went back to Istanbul, and was appointed among the teaching staff of Sahn Saman schools. Due to his extremist and liberal ideas on Islamic matters, he was accused as a heretic and was executed in January 1495 [43]. He wrote a treatise about the classification of sciences in Arabic titled *Mawdū'āt al-Ulūm* (The subjects of sciences).

In mathematics, he compiled in Arabic *Risāla fī tad'īf al-madhbah* (Treatise on Duplication of the Altar). It is a geometry book about a problem known as the *Delos Problem* [44]. Some of the book was written by him and the rest is a translation and compilation of other books on the subject [45].

4.7. Mīrīm Celebi (d. 1525)

Mahmud ibn Muhammad ibn Qādīzāda al-Rūmī, known as "Mīrīm Çelebi", was the grandson of Qādīzāda al-Rūmī (from his son) and of Ali al-Qushji (from his daughter). Born in Samarkand, he worked in Gallipoli, Edirne, and Bursa and died in Edirne in 1525 [46]. He studied mathematics under Ali al-Qushjī and was educated in various schools in Istanbul [47].

Mīrīm Celebi was a well-known astronomer and mathematician of his time. He made great contributions to the establishment of the Ottoman scientific traditions of mathematics and astronomy and was known for the commentary he wrote on the *Zīj* of Ulugh Beg and his treatises on astronomy. He composed books on mathematics and cosmology.

His book in Persian *Dastūr al-'amal wa-tashīh al-Jadwal* (Rules of operations and correction of Tables) is a commentary on Ulugh Beg's *Zīj*. A treatise with the same title containing an exposition of the treatise (*Risāla al-watar wa'l-jayb*) of al-Kāshī was written by al-Rūmī's grandson Mīrīm Celebi. This treatise is about astronomy, but the first chapter deals with mathematics. *Risāla (A Treatise): Trigonometrical part of Dastūr al-'amal wa tashīh al-jadwal* (Rules of Actions and Corrections of the Table) this part of the treatise containing exposition of determining sine 1° according to the works of Qādīzāda al-Rūmī and al-Qushji [48]. According to Woepcke, Mīrīm Celebi studied the values of trigonometric descriptions and obtained some original results [49].

4.8. Eliya Mizrahi (ca 1450-1526)

Eliya Mizrahi was born and lived in Istanbul under Sultans Muhammad II, Bayezid II (1481-1512), Selim I (1512-1520) and Suleyman I (1520-1566). He was a Jewish scholar, a descendant of Byzantine Jews (Romaniot). He possessed the highest rabbinical authority of his time and was Chief Rabbi in the Ottoman State from 1498 onwards, and also a mathematician, astronomer, physicist, and philosopher [50].

His mathematical writings include:

1. *Sefer ha-mispar* (Book of Number). Mizrahi learned decimal fractions from the Istanbul mathematicians and was a link between them and the mathematicians of Western Europe.
2. *Commentary on Euclid's "Elements"* [51].

4.9. Nasūh 'Alī al-Silāhī al-Matrākī (d. 1564)

Nasūh b. Karagöz al-Bosnawī or Nasūh b. Abdullah al-Silahī al-Matrakī, or "Matrakçi Nasūh". His family originated in Bosnia. His father or grandfather was drafted into the state service. He was a court official and renowned in the 16th century as a mathematician, historian, geographer, cartographer, topographer, musketeer, and was an outstanding knight, calligrapher and engineer. Because he was a musketeer, he was also called *al-Silāhī* (the musketeer or gunman). He was a polymath thinker, writer, and artist who pioneered a particular artistic style for depicting cities. He wrote books in these fields, all in Turkish.

He received the nickname "Matrakçi" after he created the game called *Matrak*, which means 'amazing' in Turkish (with 'çi' as a suffix). Therefore his nickname means "who plays (invents) the amazing game" [52].

Matrakçi Nasūh was educated and trained in the Palace school *Enderun* during the reign of the Bayezid II and studied with Sāī Çelebi, one of Sultan Bayezid II's teachers. During the reign of Sultan Selim I, he started to distinguish himself as a knight. He went to Egypt in 1520 for advanced studies and attended military games, at which he became unrivalled. He was given a decree on war games indicating his outstanding talent.

In the field of mathematics, Al-Matraqī wrote two books in Turkish with the purpose of facilitating the work of clerks of the state council (*Divan kâtipleri*) and the state accountants (*muḥasebeciler*). These two books are important in tracing the development of Turkish as a language to a level where it was suitable for use as a mathematical language. They are also important in following the history of the Ottoman solution of accountant's mathematical problems. It is the second most important book after Hajji Atmaca's work in this field.

A brief discussion of his mathematical books follows.

1. *Jamāl al-Kuttāb wa Kamāl al-Hussāb* (Beauty of Reckoners in the Perfectness of arithmetic). Al-Matraqī wrote his first book in 1517 and dedicated it to Sultan Selim I. *Jamāl al-Kuttāb* included two chapters. The first one is about Indian numerals, mathematical operations, fractions, scales, and measurements. Although he says that the second chapter is devoted to "miscellaneous matters", it is no extant in the surviving manuscripts [53].
2. *ʿUmdat al-Hussāb or Hisāb fī furūd al-muqaddar* (Support of arithmetic in propositions of all magnitudes). This is his second book, written in 1533. *ʿUmdat al-Hussāb* is an expanded version of the *Jamāl al-Kuttāb*. The title of the first chapter is "miscellaneous subjects"; it has twenty-two sections (fasl): 1) *siyāqāt* figures, 2) Indian figures, 3) addition of integers, 4) algebra and fractions, 5-6) duplication and mediation, 7-8) application of fractions in craft and trade, 9-11) multiplication and division of integers and fractions, 12-15) measures of length, volume, and weight, 16) drawings, 17) proportions, 18) taxes, 19) rule of "two errors", 20) addition of fractions, 21) double-false, 22) additions of fractions (*jam' kusūr ma'a kusūr*) [54].

The second chapter is entitled "solution of the 50 problems". Some figures and diagrams were added in this version. In addition to the subjects mentioned, this book also contains weights, measurements (*zira, endaze, kilajāt, qantar, misqal, dirham*), ratio, division with proportion and geometric methods, all essential for accountants. After every subject, Al-Matraqī gives examples offering new measurement divisions which were previously unknown. In the first part, the six fundamental operations of classical arithmetic are extensively

investigated for positive integers and rational numbers. In addition, the "double-false" rule used to find an exact solution for a linear equation is analysed. In the second part, several issues are explored. According to Al-Matraqī, these issues were rarely mentioned in previous works; but accountants should definitely learn them. The book deals with various other subjects, such as inheritance and tax, essential to accountants, and which are studied through examples of calculations. When Al-Matraqī wrote the second book, the first one had been almost forgotten. While we have about fifteen copies of the second book, only four copies of the first one survive. This indicates how this second book was well used by accountants.

4.10. Taqī al-Dīn ibn Ma'rūf (1520 - 1585)

Taqī al-Dīn ibn Ma'rūf was a major Ottoman scientist in the second half of the 16th century. From 1571, he settled in Istanbul, the capital of the Ottoman State and excelled in several scientific fields such as mathematics, astronomy, engineering, mechanics, and optics. The greatest astronomer of the period, Taqī al-Dīn combined the Egypt–Damascus and Samarkand traditions. He wrote more than thirty books in Arabic and Turkish on the subjects of mathematics, astronomy, mechanics, and medicine.

Taqī al-Dīn was born in Damascus and he completed his education there. He moved from Egypt to Istanbul for the third time in 1570. He was respected and appreciated by Hoja Sa'ad al-Dīn Efendi (d. 1599), the tutor of Sultan Murād III (1574–1595). In 1571, he was appointed as *munajjim bashi* (chief astronomer) by Sultan Selīm II (1566–1574). Shortly after Sultan Murād III's accession to the throne, he started the construction of the Istanbul observatory under the patronage of the Sultan. It is understood from his *Zīj* titled *Sidrat Muntahā al-Afkār* (The Nabk Tree of the Extremity of Thoughts) that he made observations in the year 1573. It is generally agreed that his famous observatory was demolished on 22 January 1580. Therefore, it can be estimated that he carried out observations from 1573 until 1580.

In addition to the existing instruments of observation, Taqī al-Dīn invented new ones such as the *Mushabbaha bi'l-manātiq* (sextant) and *Dhāt al-awtār* in order to determine the equinoxes. Moreover, he also used mechanical clocks in his observations. Taqī al-Dīn developed a different method of calculation to determine the latitudes and longitudes of stars by using Venus and the two stars near the ecliptic [55].

Starting with Ptolemy in the 2nd century CE and continuing until Copernicus in the 16th century, the Western world used chords for measuring angles. For this reason, the calculation of the value of the chord of 1° has been an important matter for astronomers. Thus, while Copernicus used the method based on the calculation of the chord of 2° that yielded an approximate value, Taqī al-Dīn used trigonometric functions such as the sine, cosine, tangent, and cotangent to measure the values of angles, in line with the tradition of Islamic astronomy. Inspired by Ulugh Beg, Taqī al-Dīn developed a different method to calculate the sine of 1°. Furthermore, he applied decimal fractions, which had been previously developed by Islamic mathematicians such as al-Uqlidīsī and al-Kashī, to astronomy and trigonometry, prepared sine and tangent tables accordingly, and used them in his work titled *Jarīdat al-Durar wa Kharīdat al-Fikār*.

Taqī al-Dīn wrote many books about mathematics and astronomy. Here are his works on mathematics:

1. *Kitāb al-nisab al-mutashākkila fī al-jabr wa al-muqābala* (Book on coinciding ratios in algebra) [56]: It was divided into a prologue, three sections and an epilogue.
2. *Bughyat al-tullāb fī 'ilm al-hisāb* (Aim of Pupils in the Science of Arithmetic) [57]: It is enclosed also in *Al-Hisāb al-hindī*, a handbook which contains the book *Hisāb al-muanjīmīn wa-'l-jabr wa al-muqābala* [58]. The codex had three chapters: 1) on arithmetic with decimal figures, 2) on arithmetic with hexadecimal figures, 3) on algebra.
3. *Kitāb tastīh al-ukar* (Book on Projecting Spheres onto a Plane) = *Dastūr al-tarjīh fī qawā'id al-tastīh* (Preferred Rule in Foundations of Projecting on a Plane) or *Tahrīr Kitāb al-ukar li-*

Thawudhūsiyūs (Exposition of "Book on Spheres" of Theodosius) [59]. It is mentioned under the first title in *Kashf al-Zunūn* of Hajji Khālifa (II, 288; III, 226). It is a treatise on stereographic projection which could be part of a larger astronomical work. The book is dedicated to Hojja Sa'ad al-Dīn Efendi and has two chapters.

4. *Risāla fī tahqīqī mā qālahu 'l-ālim Giyāth Jamshīd fī bayāni 'l-nisba bayna 'l-muhīt wa-'l-quṭr*. Taqī al-Dīn discusses here the ideas of Giyāth Jamshīd al-Kāshī's book *al-Risālat al-muhitiyya* [60].

5. Ottoman mathematicians in the 17th and 18th centuries

5.1. Khalil Fā'id Efendi

Khalil Fā'id Efendi, known as Cābizāda Halil Fā'iz (1674-1722), is a Turkish mathematician and astronomer; he worked in Istanbul [61]. Among his works we mention:

1. *Fadhlakat al-hisāb* (Concise Exposition of Arithmetic) [62]. It is a book in Turkish on astronomy but contains some mathematical issues.
2. *Al-Sawlat al-Hizabriyya fī al-Masā'il al-Jabriyya*. It is a treatise in Turkish on algebra and consists of translation of related parts of Jamshid al-Kāshī's book *Miftāh al-Hussāb fī 'ilm al-Hisāb* [63].

Two of his book were mentioned by historical sources but obviously have not survived : '*Ilm riyādīdan hisāb* (from the science of mathematics – Arithmetic) and '*Ilm riyādīdan Jabr* (From the science of mathematics –Algebra) [64].

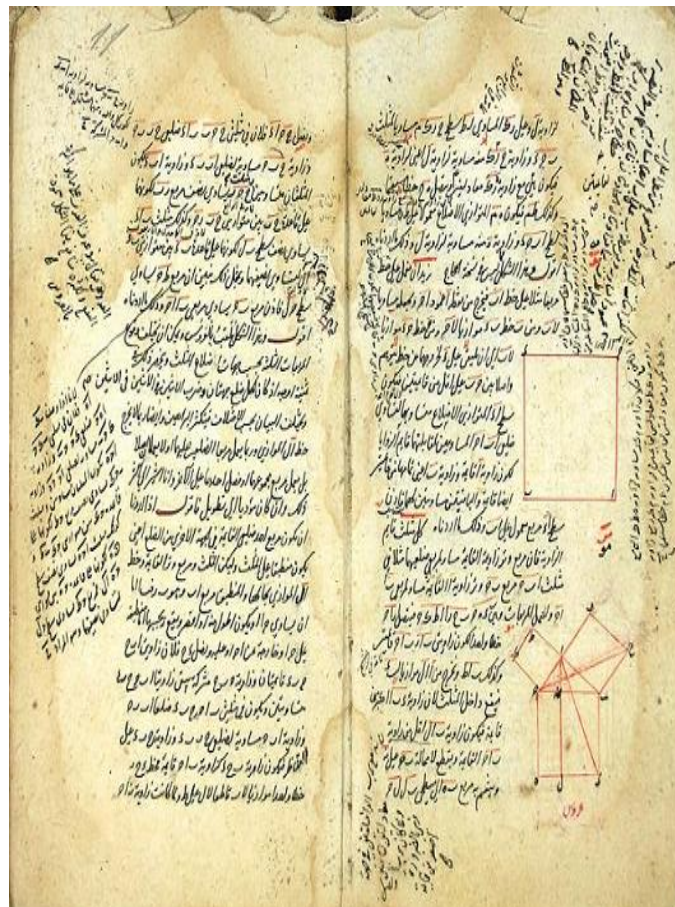


Figure 5: A sample page of an Ottoman geometry book. Source: Topkapi Palace Library, MS H 612.

5.2. As'ad Efendi al-Yanyawī (Yanyali Esad Efendi)

As'ad Efendi ibn 'Ali ibn 'Uthman Al-Yanyawī (d. 1730) was a famous Ottoman translator, mathematician and scholar [65]. He was born in Yanya, in the Balkan Peninsula, and moved to Istanbul, became *mudarris*(teacher) at various schools and judge at some cities of Istanbul [66].

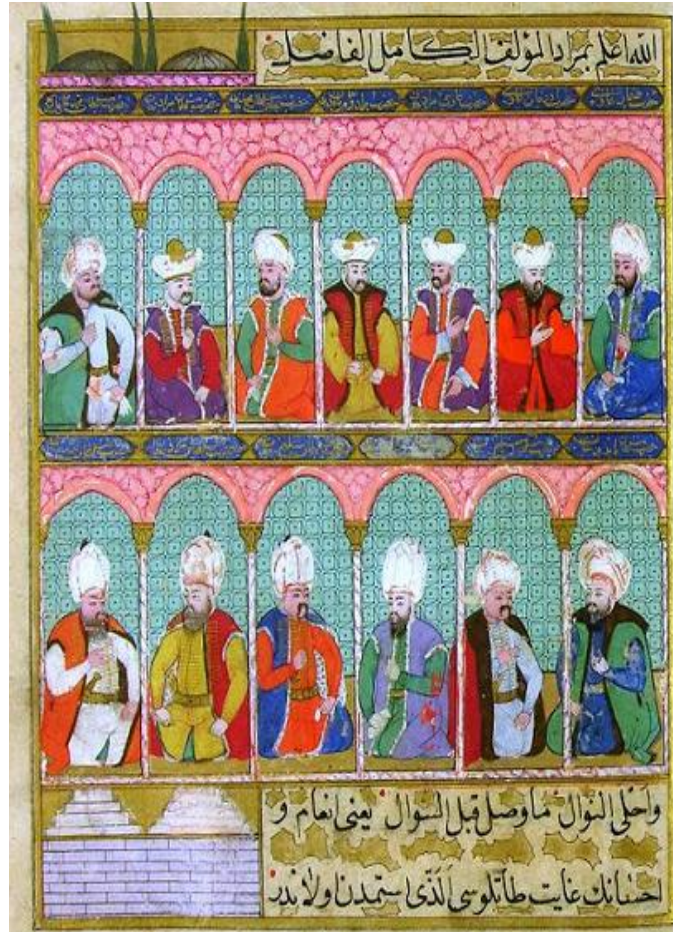


Figure 6: An Ottoman miniature depicting Ottoman Sultans. Topkapi Palace Library, MS B 373.

Among his works of mathematics we mention *Kitāb 'amal al-murabba' al-musāwī li-l-dāira* (Book on the Construction of a Square Equal to a Circle). As'ad Efendi wrote this book on geometry using Archimedes books. He also produced a translation from Latin of the book on philosophy dealing with squaring the circle[67].

5.3. Muhammad Istanbulī

Bedruddin Muhammad b. As'ad b. Alī b. 'Osmān b. Mustafā al-Yanyawī al-Islāmbulī (Istanbūlī) (d. 1733) from Istanbul. He was the son of As'ad al-Yanyawī. He was also a mathematician and astronomer [68]. He has three books on mathematics.

1. *Kitāb tathlīth al-zāwiya wa-tasbī' al-dā'ira* (Book on Trisection of an Angle and Division of a Circle into Seven Parts). This treatise covers trisection of an angle and division of a circle into seven parts.
2. *Kitāb 'amal al-musabba' wa-ghayrihī min dhawāt al-adhlā' al-kathīra fī al-dā'ira* (Book on the Construction of Heptagon and other Polygons Inscribed in Circle). It is a treatise on how to draw heptagons and polygons inside a circle using geometrical methods.

3. *Sharh Ba'd al-Makalāt al-Uklīdisiyya* (in Arabic) [69]. However, this work is not covered in the literature. Containing some problems on Euclidian geometry, this book is one of the most important works on Euclidian geometry produced during the Ottoman period [70].

5.4. 'Abd Al-Rahīm Al-Mar'ashi Efendi (d. 1736)

'Abd Al-Rahīm ('Abd al-Rahmān) ibn Abī Bakr al-Mar'ashī. A theologian and mathematician. He wrote commentaries to many works in mathematics. He was appointed as the governor of the province of Maras by Sultan Ahmet III. He educated the mathematicians Kalfaoglu and Gelenbevī. He has only one work on mathematics: *Sharh al-Risāla al-Bahā'iyya* or *Sharh 'alā Khulāsāt al-hisāb*, a commentary on the treatise of Bahā' al-Din al-Āmilī *Khulāsāt al-hisāb*. He prepared this book in one and half years and dedicated it to Sultan Muhammad IV. There are forty copies of the manuscript in world libraries [71].

His other work on the subject of mathematics deal with inheritances and contain some mathematical problems: *Tartīb al-aqsām 'alā madhhab al-imām al-Shāfi'i* (Order of division of inheritances by the method of a Shafi'i Imam) [72].

5.5. Mustafa Sidkī b. Sālih Kethüdā (d. 1183/1769)

Although he was one of the most famous Ottoman mathematicians, very little is known about his life. He was the supervisor of Sekerzāda Feyzullah Sermed. He wrote some books on mathematics and astronomy. His two works on *al-jabr wa'l-muqābala* (algebra) and measurements (*misāha*) are important [73].

They include:

1. *Risāla fī 'ilmi al-Jabr wa'l-muqābala* (Arabic). A treatise on algebra containing one prologue, three chapters, and an epilogue. It was written in 1741 [74].
2. *Risāla fī al-misāha* (Turkish). A treatise on the measurements of the fields dedicated to Grandvizier Ahmed Pasha. It contains few chapters and an epilogue. None of the copies of the book survive.
3. *Kitābu (Tahrīru) Istikhrāj al-awtār fī al-dā'i'ra bi-hawāss al-khatt al-munhanī al-wāqī' fihā (li al-Bīrūnī)* (Arabic). It is a newly edited work of al-Bīrūnī's treatise on trigonometry [75].
4. *Sharhu Tarjama-i Wardiyya Hesāb-i Jawhariyya*. It is a commentary of the poetical version of *Khulāsāt al-Hisāb* [76].

5.6. Ibrāhīm of Aleppo (d. 1776)

His full name is Ibrahim b. Mustafā b. Ibrahim Madarī al-Halabī known as "Raghib Pasha Khwājasi" or "Imam of Koca Ragib Pasha" due to the fact that he was imam of *Rais al-Kuttab* Koca Ragib Pasha. He was from Aleppo, where he received his preliminary education, and his first teacher was Salih b. Mawāhibī, sheikh of Qadirī Tarikah. Following his teacher's advice, he went to Egypt to improve his education and stayed there seven years. He studied narrative and rational sciences under the mudarris of al-Azhar named Sayyid Ali al-Zarīr al-Sivāsī al-Khanāfī. He was also taught astronomy by Hasan Al-Jabartī (d. 1774) [77]. When he went back to Aleppo, he was told that he should study narrative sciences further. During his trip on pilgrimage, he took more lessons from Abd al-Ghani al-Nablusi and Abu al-Mawahib b. Abd al-Baqī in Damascus. He continued his lessons during his visit to Makka. After pilgrimage, he went to Cairo twice. He became associated with Ali al-Sivasī at al-Azhar and gave lessons on Hanafī jurisprudence.

He became imam to Yusuf Kethuda who supported him financially and spiritually until his death. After the death of Yusuf Kethuda, Ibrahim got support from Ameer Osman, who was a veteran Sancak Bey (District ruler). He went to Istanbul as a head of a committee which was organized by some Egyptian people who had

problems with the governor of Egypt Azmizade Suleyman Pasha (1740). He stayed in Istanbul and became the imam of Koca Ragib Pasha. He copied many manuscripts for him and also taught him different sciences. He died in Istanbul and his tomb is in the Eyup district [78].

His mathematical works include:

1. *Al-Girbāl fī al-Hisāb* (Arabic). This MS contains various mathematical tables; it consists in 5940 of the boxes filled by symbols [79].
2. *Hawāshī 'ala Raqā'iq al-haqā'ik fī hisāb al-darj wa al-daqa'iq* (Arabic) (Comments on "Subtleties of Truths on Arithmetic of Degrees and Minutes"). It is a commentary of Sibṭ al-Maridīnī's book [80] which about the calculation of degrees and minutes according to the sixty base mathematics [81].
3. *Risāla fī kayfiyyat istikhrāj 'iddat al-ihtimālāt al-tarkībiyya min ayyi adad kāna* (Arabic). It is about a book on the combinatory analysis which is the largest work on this subject in the Ottoman period [82].
4. *Risāla fī al-handasa* (Arabic); on geometry [83].
5. *Sarh al-Hāwī fī al-Hisāb li-Ibn al-Hā'im* (Arabic) (Commentary on "Comprehensive arithmetic" of Ibn Hā'im). It is a commentary on Ibn Al-Hā'im's *al-Hāwī fī al-Hisāb* [84].
6. *Sharhu mas'alati taz'īf al-mazbah* (Arabic) [85].

5.7. Sekerzāda Sayyid Fayzullah Sarmad (d. 1787)

His full name is Sekerzāda Sayyid Fayzullah Sarmad b. Sayyid Muhammad b. Abdurrahman al-Istanbulī. He was born in Istanbul; his father was a very famous calligrapher. He received his elementary education first from his father and later from famous scholars of the time in Istanbul. But his preliminary mathematical education was from Mustafa Sidkī b. Salih Kathuda (d. 1769). When he completed his education, he was appointed *mudarris* at various *madrasas* and judge at various cities. He is one of the first mathematicians in the Ottoman state to write a book on logarithm and to introduce this subject into Ottoman mathematics. Like his father, he produced books on both traditional and modern mathematics. Beside mathematics, he also wrote books on astronomy. He was aware of the new studies in Europe on mathematics and related subjects. Merging traditional sciences with the modern, he combined two different traditions in his works [86].

He left several books on mathematics:

- *Maksadayn fī hall' al-nisbatayn* (Turkish), written in 1780. This is the first Ottoman treatise on logarithm. There is also information about an astronomical instrument - the *rub' muqantarāt*, a quadrant. It also explains how one can use logarithm for astronomical calculations. It is a translation and compilation from European books into Turkish [87].
- *Amthilat al-talkhīs li-Ibn al-Bannā wa al-Hāwī li-Ibn al-Hā'im* (Arabic). It is a commentary on problems mentioned in Ibn al-Bannā and Ibn al-Hā'im's treatise [88].
- *Kanz al-daqa'ik* (Arabic). It is a treatise containing tables about multiplication and division for algebra problems [89].

5.8. Gelenbevī Ismail Efendi (1730-1790)

Isma'il Efendi ibn Mustafa ibn Mahmoud al-Gelenbevī (or Kalanbawī) al-Hanafī. He was born in Gelenbe near Manisa (Turkey). He was a Turkish mathematician and astronomer, who worked also as a *madrasa* teacher [90].

Gelenbevī Ismail Efendi, the most famous mathematician of the Ottoman State in the 18th century, was born in the town of Gelenbevī in



Figure 7: Artistic depiction of Gelenbevi Ismail Efendi (1730-1790).

1737. There were famous scholars in his family. He came to Istanbul to study science, and he was also instructed in the Islamic canon law, mathematics and physics. He taught mathematics in the marine engineering school which was established by Sultan Abdul Hamit I.

His scientific works amount to more than 30. Among them we mention three Turkish treatises:

1. *Adlā'-i Muthallathāt* (Sides of a Triangle).
2. *Sharh-i lugūritma* (Explanation of Logarithms) or *Sharh Jadāwil al-ansāb-i lugūritma* (Explanation of Tables of Ratios of Logarithms).
3. *Kusurāt Hisābi* or *Hisāb al-kusūr* (Arithmetic of Fractions), also known as *Risāla fī al-Jabr wa'l-muqābala* (Treatise on Algebra).

5.9. Kalfazāda/Halifezāda Ismail Efendi (d. 1790)

Kalfazāda Ismail Efendi lived in the second half of the 18th century in Istanbul as a *muwaqqit* (timekeeper). We have very limited information about his early life and education. He was an officer in the Ottoman army and was a member of many expeditions. He received elementary astronomy education while he was very young.

When he completed his education, he was appointed as muwaqqit to Laleli Mosque Muwaqqitkhāna (Time keeping house) from 1767 until 1789. He compiled many books on mathematics and astronomy, and made some translations from European languages. He also made two sundials on the wall of Laleli Mosque and one on the table in the garden of the mosque. Beside Arabic and Persian, he also knew French, so he was able to translate Clariaut's (d. 1765) almanac *Théorie de la Lune* into Turkish as *Tarjama-i Zij Haqīm Clairautin* 1767-8 [91].

Kalfazāda Ismail Efendi's other translation into Turkish is J. Cassini's (d. 1756) almanac *Tables Astronomiques* as *Tukhfa-i Bahj-i Rassinī Tarjama Zij-i Cassini*. He added some of his own commentaries to the translation and dedicated the whole to Sultan Mustafa III in 1772-3. He added logarithmic tables at the beginning of the translation and explained how to use them. It was the first treatise in Turkish about logarithm [92]. Upon the translation of this book, Ottoman astronomers abandoned *Ulugh Beg's Zij* and started to use this almanac to conduct their astronomical calculations [93].

5.10. Huseyin Rifki Tāmānī (d. Madina, 1817)

Huseyin b. Muhammad b. Kirim Gazī was born in Taman, a province of the Crimea. He came to Istanbul at an unknown date and entered the *Muhandishāne-i Berrī-i Hümāyūn* (Imperial School of Military Engineering) in 1795 as a teacher; he was appointed chief instructor in 1806, a post he held until his death. In 1816, he first went to the Balkan Peninsula and later to Medina to renovate some buildings there. During his last duty, he passed away in Medina. Beside Arabic and Persian, he also knew French, Italian and Latin [94]. His son Emin Pasa was governor of Damascus and later on studied at Cambridge University. He first established the Military Schools and wrote a book about variations of calculations.

Rifki Tāmānī wrote and translated many books. He was one of the pioneers of the transmission of Western science into the Ottoman world via his translations. Many of his books were on physics, mathematics, military subjects and geometry. Most of his books were textbooks at school.

Here are his books on mathematics.

1. *Tarjamat Usūl-i Handasa* (Turkish). It is the translation of English mathematician J. Bonnycastle's book *Euclid's Elements* published in 1789. It was dedicated to Sultan Selim III [95].
2. *Logaritma Risālesi* (Turkish). Contains logarithm and problems with solutions. It was written in 1793 [96].
3. *İmtihan Al-Muhandisîn* (Turkish) [97]. It is a treatise on geometry and contains 88 propositions with theoretical and practical applications and solutions. It was written in 1802. There are 180 diagrams at the end of the book.
4. *Mejmua al-Muhandisîn* (Turkish). It is about military art and geometry and it was written in 1802. It mentions how to apply theoretical geometry in practical areas. Applicable geometry and measurements are also mentioned in it. At the end of the book, he provides very important information on cannon casting and various types of cannon used by the Ottomans [98].
5. *Talkhis al-Ashghāl fī ma'rifat tarfī'al-askāl fī fann al-lagim*. (Turkish). It is a treatise on geometry and most probably one of his early works. He compares French and Ottoman weight rates.

6. Some mathematicians of the 19th and early 20th centuries

6.1. Hoca Ishak Efendi

Ishak Efendi Bashhojja (1774-1836): Ottoman mathematician, astronomer, and engineer; one of the pioneers of modern sciences in the Ottoman State.

He was born in the province of Karlova, Bulgaria. He was an engineer who worked as chief instructor in the Imperial School of Engineering (Muhandishāna Bahrī-i Humāyūn). He knew Arabic, Persian, French, Greek and Latin. He translated many books from western languages into Turkish.

Among his thirteen books, which he wrote using Western and particularly French sources, *Mecmūat-i 'ulūm-i Riyādiyya* (Compendium of Mathematical Sciences, four volumes) is of special importance, since it is the first attempt in any language of the Muslim world to present a comprehensive textbook on different sciences such as mathematics, physics, chemistry, astronomy, biology, botany, and mineralogy in one compendium. Ishak Efendi's efforts to find the equivalents of the new scientific terminology and his influence on the transfer of modern science spread in other Islamic countries beyond Ottoman Turkey.

He was instrumental in introducing modern sciences to the Islamic world through his numerous translations, adaptations and compilations from European languages, thus furthering the progress of education. He made significant contributions to Ottoman science by developing modern scientific terminology. Apart from mathematical books, he wrote some books about military building and production [99].

Among his books on Mathematics, we mention:

- *Majmu'āt-i 'ulūm riyādiyya* (Collection of Mathematical sciences). In this work, he explained all mathematical concepts and methods with their applications to engineering and science. It was an important course book of its period for general and applied mathematics.
- *Ajsam nāriyya wa muthalathāt kuriyya* (Fire solids and Spherical Triangles).

6.2. Ahmad Tawfīk Efendi (1807-1869)

He was the son of Isma'il Hakki b. Mustafa Salih al-Bursawī who was a member of Ashrafoglu Rumī's family. He received his preliminary education in rational and narrative sciences in Istanbul from Kathudazāda

Muhammad Arif Efendi and entered the *ilmiyya* (Scholars) class. He had several government posts including as a judge of Makka and Madina. He gave private lessons to those who wished to learn mathematics, astronomy and similar subjects. He composed some important books on mathematics, such as those following below:

- *Hall al-As'āb fī taz'īf al-Muqā'ab* (Turkish). It is a book about the square of cubic numbers [100].
- *Majmu'āt al-farā'id wa lubb al-fawā'id* (Turkish). It is a book written in 1826 about applied geometry and measurements [101].
- *Nukhbat al-Hisāb* (Turkish). It is a book about mathematics, measurements and geography. It was divided into one epilogue, seven chapters (*maqala*) and one prologue. He completed the book in 1830, dedicated and presented it to Sultan Mahmud II [102].
- *Talkhīs al-A'māl* (Turkish). It is a basic book for the mathematical subjects. It was divided into an introduction (*muqaddima*) and four chapters (*fann*). It was also dedicated to Sultan Mahmud II [103].

6.3. Hüseyin Tevfik Pasha of Vidin (1832-1893)



Figure 8: The Photo of Vidinli Tevfik Pasha.

During the westernization process of the 19th century, scientific studies, in the Ottoman world did not go beyond translation of European books into Turkish. In this atmosphere, Tevfik Pasha of Vidin (mostly known as Vidinli Tevfik Paşa in Turkish literature) researched on the very new area in mathematics –the quaternion, and published a research book in English on this subject entitled *Linear Algebra*. It was first published in 1882 (169 pages) and a second revised and enlarged version was published in Istanbul in 1892 by A. H. Boyajian (188 pages). Tevfik Pasha was the first scholar in the history of the Ottoman scientific tradition to perform such an innovative research on linear algebra and publish a book in this original field.

The book *Linear Algebra*, written and published in English, is an original work on a very new mathematical subject of the time, the quaternion. Quaternions were first invented by the Irish mathematician-astronomer W. R. Hamilton (d. 1843) and became very important when they were applied to physics. This book mainly discusses this subject and at the end, the author established three dimensional algebra, which contains the algebra of complex numbers and also formed with the three dimensions space vectors league. He also demonstrated

the application of this method to various problems which belong to elementary geometry.

Hüseyin Tevfik's book was one of the world's earliest printed books on this subject and it kept its originality until the 1920's.

Other mathematical works by Tevfik include:

- *Hisāb Muthanna* (Dual Algebra): An article about algebra in English published in the journal *Mebāhis Al-İlmiye Mecmuası* in 1866.
- *Zayl Usūl al-Jabr* (Appendix on the method of Algebra) (Turkish). An appendix about derivatives upon Tahir Paşa's book *Usūl al-Jabr* and also about Taylor and McLaurin series. (İstanbul 1278/1861).

Yeni Ölçülerin Menāfi ve İstimāline Dāir Risāla-i Muhtasara (An Abridged treatise on the advantages and usage of the new measurements) (Turkish): The book explains how to solve problems of the newly established system of weights and measurements (İstanbul 1882).

According to the sources that mention his life we know he wrote more books which we cannot place so far. *Jabr-i Hattī* (Algebra on surface), *Usūl-i İlmi hisāb* (Turkish) (Method on the science of calculation) and *Jabr-i a'lā* (Turkish) (High Algebra).

6.4. Salih Zeki (1845-1921)



Figure 9: The Photo of Salih Zeki.

Salih Zeki is a mathematician who wrote extensively on musical subjects, stating that whereas the "science" of music, and its analytical methods, was common to all people, the music itself was peculiar to each people alone.

He studied electrical engineering in Paris. After returning to Turkey he worked first as an engineer in the Mail and Telegraph Administration and then as a mathematics teacher. He left his job as an engineer to devote his life to teaching and to spreading knowledge of mathematics. He worked also as the director of an observatory. He established the mathematics department in the science faculty at Dār al-Funun (Today Istanbul University). He wrote many books on mathematics, some of which are *Asari Baqiya*, *Kāmūsu Riyādāt*, *Hiqmati Tabiiyai Umūmiya*, *Hisābi İhtimālāt*, *Mīzan Tafakkur*.

Asari Baqiye is about arithmetic, trigonometry, geometry and cosmology. *Kāmūsu Riyādāt* is a mathematical encyclopaedia. *Hiqmati Tabiiyai Umūmiya*, is about general physics. *Mīzan Tafakkur* is an important book about the logic of algebra. Salih Zeki was also a historian of science.

7. Conclusion

Mathematical studies in the Ottoman State began with Ali al-Qushjī in Istanbul and continued until Salih Zeki's period. These works were divided into two styles: traditional and Western. The traditional ended with Gelenbevi's works and the Western style ended with Salih Zeki's work. Ottoman mathematical studies continued over five centuries, but this tradition could not keep up with the developments in mathematics in Europe since the 18th century. In the Ottoman school, some mathematicians produced original works but others were satisfied with education and the publishing of books on mathematics. Most of works of the Ottoman school were not studied in detail from the point of view of the history of mathematics. There are two reasons for this. The first reason is that there are very few people with an interest in the subject and the second is that the young people in Turkey cannot read and understand the texts written in the Arabic language. Because of these facts, I think that it will take a long time to study the Ottoman texts. I hope that if the Ottoman texts written in the 15th, 16th and 17th centuries are studied in detail, it will be possible to find out the level of the Ottoman mathematics and contributions to world civilization. To find out Ottoman mathematical works in manuscripts, one must research and analyze books on astronomy, geometry and cosmology as well. Some parts of these works contain very important and original areas of mathematics. For example, some books on astronomy give very important information for problems of spherical and geodetic astronomy. To understand and write the full history of Ottoman astronomy, related books should also be considered.

Ottoman scholars lived with mathematics. They were well informed of the work of other scholars and they made many original contributions to mathematical research and education. Some of these contributions were translated into other languages and were used as textbooks. Traditionally all Ottoman mathematicians were also interested in other branches of science branches such as astronomy, science and engineering and made important contributions to these fields. Unfortunately, the history of Ottoman mathematics is one

of least researched fields in the history of mathematics of the Islamic civilisation. There are many original works of Ottoman mathematicians in the libraries of Turkey which have not been studied from the perspective of scientific history. If these were to be studied in detail, a clearer picture of Ottoman mathematics would become visible.

8. References

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Footnotes

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- [2] İhsan Fazlıoğlu, "Davud Kayseri", *Yaşamları ve Yapıtlarıyla Osmanlılar Ansiklopedisi*, İstanbul: Yapi Kredi Yayınları, 1999, I, 370-371.
- [3] Katip Celebi (d. 1658) claims that, in his time, the interest in rational sciences decreased, and that in time they were excluded from the *madrasas* teaching. However, his viewpoint should be re-examined in the light of historical facts and in the broader context of the development of the cultural and intellectual life in the Ottoman capital, especially in the seventeenth century. The ample evidence we have in the rich Ottoman scientific literature surveys published by IRCICA indicates a progressive curve in the inclusion of the rational sciences and does not confirm Katip Celebi's statement. For a critical evaluation of Katip Celebi's words, see İhsanoglu (1996, p. 39-84) and İhsanoglu (2004).
- [4] For the copies of the first book see OALT 1. pp. 9-21; for the second book OMLT I, pp. 7-18.
- [5] Cevat İzgi, "Osmanlı Medreslerinde Aritmetik ve Cebir Eğitimi ve Okutulan Kitaplar", *Osmanlı Bilimi Araştırmaları*, no. 3401, (1995).
- [6] *Ibid.*
- [7] This book was printed in Roma: *Kitab Tahrir Usul li-Uqlidis min ta'lif khwaja Nasir al-Din al-Tusi. Euclidis elementorum geometricorum libri tredecim. Ex traditione doctissimi Nasiridini Tusini. Nunc primum Arabice impressi*. Romae: in Typographia Medicea, 1594.
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- [9] *Ibid.*
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- [11] For the list of the copies of the MS see: OMLT, I, 290-293.
- [12] İhsan Fazlıoğlu, "Cebir", *Diyanet İslam Ansiklopedisi*, İstanbul 1993, VII, 199.
- [13] Although it is not an algebra book, it contains some problems related to algebra. OMLT, I, 132-134.
- [14] *Ibid.*
- [15] *Ibid.*
- [16] Ekmeleddin İhsanoğlu, "Some Remarks on Ottoman Science and its Relation with European Science & Technology up to the End of the Eighteenth Century," Papers of the First Conference on the Transfer of Science and Technology between Europe and Asia since Vasco da Gama (1498–1998). *Journal of the Japan–Netherlands Institute* 3: 45–73, 1991.

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- [18] Rosenfeld, p. 378.
- [19] Rosenfeld, no 808, M2.
- [20] *OMLT*, I, 6-18.
- [21] Rosenfeld, no 808, M3; no. 802, M4.
- [22] *OMLT*, I, 3-5.
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- [30] To see the copies of the MSS see: *OMLT*, I, 34-35.
- [31] Rosenfeld, p. 288.
- [32] To see the copies of the MSS see: *OMLT*, I, 35.
- [33] *OMLT*, I, 36.
- [34] Rosenfeld, p. 290 (nr. 858): Hoca Sadettin, *Tâc al-tawârih*, İstanbul 1280, II, pp. 498-500; Hajji Khalifa; *Kashf al-zunun*, II, pp. 1819, 1236, 1311; Adnan Adivar, *Osmanlı Türklerinde İlim*, İstanbul 1982, pp. 49-50; Ibn al-Imâd, *Shazarât al-zahab*, Cairo 1350, VII, pp. 351-352; C. Woodhead, "Sinan Pasha, Khodja", EI2, s. 630-631; Cevat İzgi, *Osmanlı Medreselerinde İlim*, I, s. 299, 385, 403.
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- [51] Rosenfeld, no. 943.
- [52] Salim Ayduz, "Nasûh Al-Matrakî, A Noteworthy Ottoman Artist-Mathematician of the Sixteenth Century".
- [53] Rosenfeld, no. 1001 M1; *OMLT*, I, 69.
- [54] Rosenfeld, no. 1001 M2; *OMLT*, I, 70-73.
- [55] On the work of Taqî al-Din, see the special section devoted to him on www.MuslimHeritage.com: Taqî Al-Din: [Astronomy](#), [Mathematics](#), [Optics and Technology](#).
- [56] Cairo (Miqat 557/3, 4 f., Taymur Riyada. 140/10), Oxford (I 88/3).
- [57] Cairo (Riyada. 1023), Rome (Vatican Sbath 496/2). It is quoted in *Qāmūs al-Riyādhīyyāt* of Salih Zeki (vol. II, p. 59).
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- [59] Cairo (Tal'at miqat 135 - anonymous), İstanbul, MS Kandilli 415/5, 12 folios.

[60] İstanbul, Kandilli, nr. 208/8, 5 f.

[61] Rosenfeld, no. 1314.

[62] İstanbul, Veliyuddin 2330.

[63] *OMLT*, I, 168-169.

[64] Rosenfeld, no. 1314.

[65] Rosenfeld, no. 1327.

[66] *OMLT*, I, 175-176.

[67] Cairo (Taymur riyada 140-16- a fragment).

[68] Rosenfeld, no. 1291.

[69] Bursali Mehmed Tahir (1342), III, 257.

[70] In the introduction of this MS, Bedruddin Muhammad mentions the names of Sultan Ahmed III., Grand Vizier Ibrahim Pasha and Shaikh al-Islam Ebezade Abdullah Efendi. In the introduction to his work, he claims to have spent some time working on geometry, that he trisected angles, divided circles in seven and arcs in six parts and solved many problems which had not been solved until his time. The figures were given on the sides of the book. The only copy of the book is at Bayezid State Library, Umumi, MS 9787.

[71] İhsan Fazlıoğlu, "Abdürrahim Maraşî", *Yaşamları ve Yapıtlarıyla Osmanlılar Ansiklopedisi*, İstanbul 1999, I, 73.

[72] Hajji Khalifa, *Kashf al-zunun*, II, 1349, 1350; Rosenfeld, no. 1251; *OMLT*, I, 180-184.

[73] *OMLT*, I, 214-217; Cevat İzgi, *Osmanlı Medreselerinde İlim*, I, 232-233; İhsan Fazlıoğlu, "Hendese", *Diyanet İslam Ansiklopedisi*, XII, 206; İ. Fazlıoğlu, "Hesap", *Diyanet İslam Ansiklopedisi*, XII, 244-271.

[74] Süleymaniye library, Yazma Bağışlar, MS 1347/8, 5 folios.).

[75] Dâr al-kutub al-Misriyya, Mustafa Fazil, Riyada, MS 41/11, 8 folios.

[76] İstanbul Üniversitesi Library, TY, MS 6845, 25 folios.

[77] Rosenfeld, no. 1367.

[78] Cevdet, *Tarih*, IV, 214; Muradî, *Silkü'd-dürrer fî a'yânî'l-karnî'l-hādî aşer*, Bulak, 1301, c. I, 37-39; *GAL*, II, 311, *GAL*², II, 428; Ziriklî, I, 69; Kehhale, I, 112, 113; *İzāhu'l-meknûn*, II, 240, 429; İsmail Paşa, I, 39; *İ'lāmu'n-nübelā*, VII, s. 93-95; *Kamusülalām*, I, 568, 569; *SO*, I, 136; Ebulula II, 273; İzgi, I, 232, 328, 386; A. Özel, *Hanefî Fikih Âlimleri*, Ank., 1990, s. 144; İ. Fazlıoğlu, "Hendese", *DİA*, XII, 206; *OMLT*, I, 222-227. Salim Aydıöz, "İbrahim Halebî", *Yaşamları ve Yapıtlarıyla Osmanlılar Ansiklopedisi*, İstanbul 1999, I, 627-628.

[79] Süleymaniye library., Yazma Başılar, MSS. 2060, 50 Folios.

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[81] Süleymaniye Library, Esad Efendi, MS 1953, 61 folios.

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[84] Rosenfeld, No, 783, M22.

[85] Köprülü Library, III. Kisim, MS 709/6, 5 folios.

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[87] Kandilli Rasathanesi Ktp., nr. 209; Süleymaniye Kütüphanesi Giresun Yazmalar, 3633.

[88] Süleymaniye Ktp., Esad Efendi, nr. 3150/2, folios 10a-109b.

[89] Süleymaniye Ktp., Reşid Efendi, nr. 989/16.

[90] Rosenfeld, no. 1390.

[91] Kandilli Rasathanesi Ktp., nr. 190, 30 v.

[92] Kandilli Rasathanesi Ktp., nr. 200, 199 v.

[93] Salih Zeki, *Kamûs-i Riyâziyyât*, I, s. 327-330; OM, III, s. 259-260; SO, I, s. 371-372; Uzunçarşılı, *Osmanlı Tarihi*, IV/II, s. 537; OALT, s. 530-536; Adivar, s. 199-201.

[94] Mehmed Esad, *Mirat-i Mühendishâne-i Berrî-i Hümayûn*, İst., 1312, s. 27, 32, 33; A. Sayili, "Turkish contributions to and reform in Higher education and Hüseyin Rifki and his work in geometry", *Ankara Üniversitesi Yıllığı*, XII (1966), s. 90-98; S. Tekeli, *Hüseyin Rifki Tamanî*, Arap Bilimler Tarihini Araştırma Cemiyeti tarafından düzenlenmiş olan ikinci Uluslararası konferansta sunulan tebliğ, 5-6 Nisan 1977; TA, XIX, s. 425; K. Beydilli, *Türk Bilim ve Matbaacılık Tarihinde Mühendishâne ve Mühendishâne Matbaası ve Kütüphânesi (1776-1826)*, İst., 1995, s. 50-56, 284, 309-311; M. Kaçar, *Osmanlı Devleti'nde Bilim ve Eğitim Anlayışındaki Değişmeler ve Mühendishânelerin Kuruluşu*, İÜ Sosyal Bilimler Ens., doktora tezi, 1996, s. 151, 205.

[95] TSMK, Hazine, no. 602/1, 167 vr.

[96] Kandilli Rasathanesi Ktp., no. 216, 15 vr.

[97] TSMK, Hazine, no. 604, 70 vr.

[98] TSMK, Hazine, no. 601, 143 vr.

[99] Rosenfeld, no. 1407.

[100] *OMLT*, I, 314.

[101] *OMLT*, I, 314-315.

[102] *OMLT*, I, 315-316.

[103] *OMLT*, I, 316-318.